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EFFECT OF DIAPAUSE ON DEVELOPMENT AND REPRODUCTION OF WHITE RICE STEM BORER *SCIRPOPHAGA INNOTATA* WALKER (LEPIDOPTERA: PYRALIDAE)

PENGARUH DIAPAUSE TERHADAP PERTUMBUHAN DAN PERKEMBANGAN PENGGEREK BATANG PADI PUTIH, SCIRPOPHAGA INNOTATA *WALKER (LEPIDOPTERA: PYRALIDAE)*

Teddy Suparno
Faculty of Agriculture, University of Bengkulu
Jl. Raya Kandang Limun 38327 Bengkulu, Indonesia

INTISARI

Tujuan dari penelitian ini adalah untuk mendeterminasi pengaruh diapause pada perkembangan dan reproduksi penggerek batang padi putih (PBPP), Scirpophaga innotata *Walker. Selama diapause berat larva PBPP turun secara progresif dengan laju penurunan 3,2 mg per minggu. Pada ganti kulit keempat setelah memasuki diapause, berat badannya berkurang 50% dari berat awal ketika memasuki diapause. Larva menjadi kurang aktif, pigmentasi hilang dan tungkainya mengalami kemunduran. Makin lama berdiapause, mengakibatkan berat ngengat yang muncul makin ringan dengan lebih sedikit telur dan oosit. Setelah 5 bulan dalam diapause, berat ngengat yang muncul sekitar separo dan jumlah telur dan oosit (230.0 ± 35.8 sel telur dalam ovari) yang dihasilkan sekitar setengah dibanding dengan ngengat yang muncul dari yang tidak berdiapause.*

Kata kunci : Serangga, penggerek batang padi putih, Scirpophaga innotata, *diapause.*

ABSTRACT

The objective of this study was to determine the effect of diapause on development and reproduction of white rice stem borer (WRSB), *Scirpophaga innotata* Walker. During diapause, larvae of the WRSB, progressively decreased in weight at the rate 3.2 mg per week. Larvae lost 50 per cent of their initial body mass and had up to four stationary molts. Larvae became less active, lost pigmentation and leg rudimentary. The longer the larvae remained in diapause, the lighter in weight the emerging moths were, with fewer eggs and oocytes. After 5 months in diapause, the emerging moths weighted about half as much and had about half as many eggs and oocytes (230.0 ± 35.8 egg cells in ovaries) as moths that emerged from nondiapausing larvae.

Key words: Insecta, white rice stem borer, *Scirpophaga innotata*, diapause

INTRODUCTION

White rice stem borer (WRSB), *Scirpophaga innotata* Walker, is a tropical rice pest. It has been observed on rice in Pakistan, South India, Vietnam, Indonesia, Serawak, Philippines, and Northern Australia (Banerjee & Pramanik 1967, Rothschild 1971, Goot 1930, Halteren & Mas 1977, Learmonth 1979). In Indonesia, WRSB can be found in Java, Sumatera, Kalimantan, South Sulawesi, Lombok and Sumbawa (Oka 1991). However, WRSB with a diapause strategy are found only in Java (Triwidodo, 1993). In Java, WRSB occurs only in lowland rice plantations (up to 200 m altitude) with pronounced wet and dry season, as on the north coast of Java (Goot, 1925). Diapause incidence of WRSB occurred in long dry season (May to November) 1997 on rice field at Kandang Limun (located at 3.4°S), west coast of Bengkulu (Suparno 1998, unpublished).

WRSB is a monophagous insect known to feed only on rice and recorded as the most important lepidopterous stem borer on rice plantation along the north coast of Java. From 1900 to 1940, it was found in paddy fields along the north coast of Java. From 1940 to 1988, populations this insect

disappeared from the area, and are presently found only in paddy fields along the north coast of West Java. The decline of WRSB population on Java was related to the increase and improvement of irrigation system.

In the growing season 1989/1990, sudden occurrece of WRSB outbreak happened in Java. However, the outbreak took place only in a central rice production area in the north coast of West Java, particularly at rice were plantations that fallow during the dry season (June to October). This insect outbreaks caused damage to 75,000 hectare with rice crop yield loss about $US 30 million (Oka, 1991).

WRSB survives at the off-rice season as a diapausing larvae. Five to seven generations developed during the rice growing season (Goot 1925), and at the end of the season, the last larva living in the maturing rice plant bored downward to the base of rice tiller and went into a diapause state during the dry off-rice season. The larva would become less mobile but might molt several times before residing in the stem below the soil surface.

Diapause of WRSB was first reported by Dammerman (1915) along the north coast of Java, where rice was planted once a year during rainy seasons. He observed that after harvest WRSB larvae remained in the rice stubles in a resting condition as long as the dry monsoon lasted (May to October), where they are protected from natural enemies and well insulated against adverse climatic condition. At the beginning of the following rainy monsoon, the larvae would pupate, and the moths that subsquently emerged laid eggs on seedbeds of the next rice crop. These diapause phenomena unchanged until present. This study was to determine the effect of diapause on development and reproduction of WRSB.

MATERIALS AND METHODS

The research were conducted in the green house at the Bogor Research Institute for Food Crops (BORIF) and in the laboratory at the National Biology Institute, Bogor, January to December, 1994. Two hundreds of diapausing sixth instar of WRSB were collected from rice (*Oryza sativa* L.), field at the end the growing season in Karawang, north coast of West Java Province (6.5°S, elevation 5 - 20 m) in May 1994. All larvae were provided with a section of dry rice stubble and kept singly in glass vials (10 by 2.5 cm) plugged with cotton wool. All vials were kept at 30 ± 2°C and 75 ± 10 % RH. Larvae were examine weekly and mortality, molts, widths of head capsules and mandibles of exuviae were recorded. Moisture or rainy period were needed for diapause termination (Goot 1925, Triwidodo 1993). Moistening were conducted at 3, 4, 5 and 6 months into diapausing larvae. Pupation and moth emergence were recorded. Pupae were inspected daily, and random samples of female moths were collected upon emergence to determine body mass and the number of egg cells in ovary. For comparison, the body mass and number of egg cells were also recorded for moths that emerged from nondiapausing insect reared in the green house or collected in the field. From the field, insect were collected as fifth instar or pupae and held under similar conditions as describe above. Because nondiapausing larvae need food, fresh section of rice stem were provided instead of the rice stubble. These insects normally emerged as moths within 1 - 2 weeks. To determine the weight loss during diapause, 25 sixth instar WRSB were randomly selected. At fortnightly intervals untill adult emergence, their body mass was measured, data for borers that died as larvae or pupae were discarded. The weight of the adults was also determined upon emergence. Data obtained for 11 WRSB that survived and emerged adults.

The data on body mass and number of egg cells in ovaries were subjected to a linear regression analysis and to an analysis of variance using the general statistical program Irristat 1990. The means across months were separated using a multiple comparison LSD Boferroni t-test, to

contrast no diapausing larvae from diapausing larvae and duration of diapause. The mean separation were performed an untransformed data.

RESULTS AND DISCUSSION

WRSB is an unique monophagous insect, the larva only feeds on rice plant. The adults do not feed because their mouthparts were rudimentary and had a short life (about 7 days). All organic substances which had required in growth, development and reproduction were accumulated by larvae before pupation or before entering diapause. Diapause larvae of WRSB progressively decreased in weight the rate of 3.2 mg per week (Fig. 1). The greatest loss of body mass occurred during the first 2 week in diapause. Because in this period the physiological process is still normal which then slowed down in later period. During the larval stage WRSB borers lost ≈ 50% of the body mass (Table 1). While WRSB larvae in diapause, they consume the energy reserves which affected the loss of their body mass, the longer the period the bigger the loss. Another 8 % was lost during the pupal stage and the resulting WRSB moths retained only ≈ 20% of the body mass of the sixth instar at the start of diapause (Table 1).

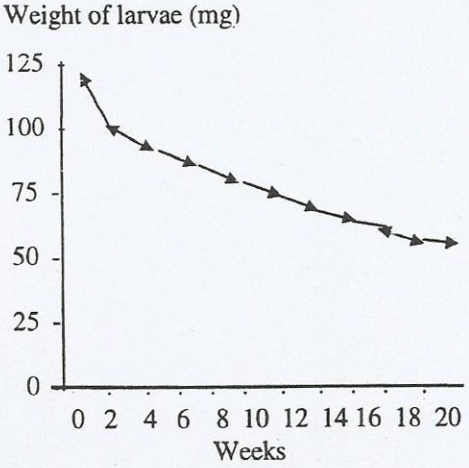

Figure 1. Weight of sixth instar WRSB during diapause.

Table 1. Weight loss by WRSB during diapause of larvae, pupation and emergence of moths

Stage	Body mass (mg) Mean ± SE	Weight loss (%)
Collected larvae	121.42 ± 13.15	-
Larvae before pupation	58.29 ± 6.75	52.47
Pupae	44.05 ± 5.47	60.27
Moths	28.11 ± 4.14	78.04

n = 11

During early development, a diapausing larvae (i.e. sixth instar) could be differentiated from the fifth instar by its larger body sizes, a more intense yellow color, and more visible dorsal blood vessel. Also, diapausing larvae were invariably found with their heads oriented in a downward position, whereas the fifth instar were invariably found with their heads oriented in an upward position. The later stage of diapausing larvae were found in the lowest nodes of the rice stubble below grown level, were immobile with rudimentary legs and were often protected by tight, silky cocoons.

During diapause, up to five and four stationary molts occur in WRSB. This indicates that some larvae molted as many as nine times before pupation as compared with the normal five molts for nondiapausing larvae. It has been reported that other insects also molt when in diapause larvae of *Busseola fusca* (Fuller) and *Chilo partellus* (Swinhoe) in South Africa molted irregularly three times more during diapause (Kfir 1991). In Trinidad, larvae of *Diatraea lineolata* may molt once or twice more during their resting stage (Kevan 1943), and in Nigeria up to six additional molts were recorded for *B. fusca* larvae (Usua 1970). More than three stationary molts occurred during diapause in only 5% of the larvae.

Larval head capsules split or broke and were not suitable for accurate measurements. Six head capsules were the longest series that were unbroken and could be measured. After the five molts the widths

of head capsules and mandibles of WRSB progressively decreased by ≈ 20% (Table 2). As the insect's external skeleton cannot expand while larvae grow, insect must molt. However, when larvae lose body weight as they consume their energy reserves during diapause, the skeleton becomes too large for the shrunken larvae, and this might trigger an additional molt and the formation of smaller skeleton.

Table 2. Reduction in head capsule and mandible widths of larvae of WRSB during diapause on rice variety IR64

No. stationary molts	Head capsule width, (Mean ± SE) mm	Mandible width, (Mean ± SE) mm
1	2.05 ± 0.023	1.90 ± 0.05
2	1.93 ± 0.024	0.96 ± 0.04
3	1.90 ± 0.021	0.93 ± 0.06
4	1.86 ± 0.016	0.83 ± 0.04

Female moths that emerge from nondiapausing larvae were heavier and their ovaries contained more eggs and oocytes than moths that emerged from diapausing larvae (Table 3). As expected the longer the period of larval diapause, the lighter the emerging moths were, with fewer eggs and oocytes in their ovaries, since they consume a lot of energy reserve for metabolisms activity during in diapause. The longer the period of larval diapause needs more energy or food storage. The body mass of moths that resulted from nondiapausing larvae and the number of eggs and oocytes in their ovaries was about twice that of moths emerging in November after 6 months of diapause (Table 3). A linear correlation between body mass of female moths (X) and number of eggs and oocytes (Y) in their ovaries was found $Y = 111.90 + 5.67 X$, $r = 0.81$, $P < 0.01$, $n = 120$.

As was found for other insects, the reproductive output increased with female size. Larger WRSB females laid heavier batches with more and larger eggs. Larger eggs probably contain more yolk or vitellogenine, which could be important for the ballooning behavior of newly hatched larvae and for their survival (Berger, 1989). This may contribute to the more severe borer infestations later in the season that occurred each year in West Java. The lighter borer infestations at the beginning of the season (October to November) are caused by first generation, low fecundity moths emerging from diapausing larvae. Later in the season (December to April), the severe infestations are caused by heavier, more fecund moths emerging from nondiapausing larvae.

Table 3. Body mass and number of egg cells in ovaries of WRSB female moths emerging from nondiapausing and diapausing larvae collected from rice field in Karawang and larvae reared in green house

Time of emergence	Diapause period mo	n	Body mass (mg) [a] (Mean ± SE)	No. egg cells in ovaries[a] (Mean ± SE)
January	-	17	68.1 ± 3.7d	430.0 ± 30.1bc
February	-	9	63.7 ± 5.1cd	405.0 ± 41.3bc
March	-	9	67.8 ± 5.1d	433.0 ± 41.3bc
August	3	11	54.7 ± 4.6bc	346.0 ± 37.4ab
September	4	26	49.3 ± 3.0ab	381.0 ± 24.3b
October	5	22	43.4 ± 3.3ab	373.0 ± 26.4b
November	6	12	37.8 ± 4.4a	230.0 ± 35.8a
Greenhouse culture	-	14	88.3 ± 4.1e	481.0 ± 33.1c

[a]Values within a column followed by the same letter are not significantly different $P < 0.05$ multiple comparison LSD Bonferroni t test

CONCLUSION

During diapause, larvae of the WRSB, progressively decreased in weight at the rate 3.2 mg per week. Larvae lost 50 per cent of their initial body mass and had up to four stationary molts. Larvae became less active, lost pigmentation and leg become rudimentary. The longer the larvae remained in diapause, the lighter the weight of the emerging moths were, with fewer eggs and oocytes. After 5 months in diapause, the emerging moths weighted about half as much and had about half as many eggs and oocytes as moths that emerged from nondiapausing larvae.

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